DOCUMENT RESUME

ED 079 328 TM 002 926

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TITLE Relations Between Cognitive Abilities and Concept Attainment.
INSTITUTION Wisconsin Univ., Madison. Research and Development Center for Cognitive Learning.
SPONS AGENCY Office of Education (DHEW), Washington, D.C. Research and Development Centers Branch.
PUB DATE 26 Feb 73
NOTE 10p.; Paper prepared for a Symposium of American Educational Research Association Meeting (New Orleans, Louisiana, February 25-March 1, 1973)

EDRS PRICE MF-$0.65 HC-$3.29
DESCRIPTORS *Achievement Tests; *Cognitive Ability; *Concept Formation; Females; Males; Measurement Techniques; Speeches; Statistical Analysis; *Student Testing; *Test Results

ABSTRACT

The results obtained from the studies in the first strand, including evidence of replicability or findings, are summarized. Main emphasis is on the findings of the Structure of Concept Attainment Abilities Project with respect to the study of the relations between the two sets of variables. The number of dimensions and the character of the dimensions which are common to the two types of variables are described. (Author)

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Symposium: The Structure of Concept Attainment Abilities Project
Final Report and Critique

RELATIONS BETWEEN COGNITIVE ABILITIES AND CONCEPT ATTAINMENT

TM 002 926

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A paper presented at the annual meeting of the
American Educational Research Association
February, 26, 1973
New Orleans

The material reported herein was prepared with the support of the Wisconsin Research and Development Center for Cognitive Learning, supported in part as a research and development center by funds from the United States Office of Education, Department of Health, Education, and Welfare. The opinions expressed herein do not necessarily reflect the position or policy of the Office of Education and no official endorsement by the Office of Education should be inferred.
Center No. C-03 / Contract OE 5-10-154

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Mrs. Quilling has described the purpose and scope of the project, and Mr. Harris has discussed problems of methodology encountered in the project. I will now summarize certain findings. The project was vast in scope, in methods used, and in findings which we think are interesting; all I can hope to do here is touch upon the highlights.

SUMMARY OF CONCEPT ATTAINMENT FACTORS

A summary of the concept attainment factors is given in Table 1 of the handout; the order of the factors is arbitrary. The similarities in the results across two types of achievement measures, concepts and tasks; two types of analyses, single subject matter and combined subject matters; and four different samples, 1970 and 1971 boys and girls, can be seen clearly. A general observation is that the results are essentially the same for each of the analyses.

In the 1970 and the 1971 analyses made separately for concepts and for tasks of a single subject matter, the interpretation of the results of each analysis is that a single common factor exists. In the 1971 analyses of combined concepts and combined tasks, there is a comparable common factor for each of the subject matter fields except that in the combined tasks analysis for boys, science and social studies tasks appeared on the same factor (CCF 3). For the combined concepts some science concepts appeared on the social studies factor for both boys and girls (CCF 4). CCF's 5, 6, 7, and 8 for combined concepts exist only for girls. Each of these consists of a small number of concepts from one of the four subject matter fields. For combined tasks, CCF 5 consists of Task 7 for all four subject matters for both boys and girls; in addition, Task 12 for mathematics and social studies appears on CCF 5 for boys and Task 12 for science and social studies appears for girls. CCF 6 for combined tasks

exists only for girls and consists of Tasks 3, 4, and 5 for science.

These general conclusions seem to be warranted. Within each subject matter field, when studied separately, a single factor is adequate to describe the concept variables, and similarly a single factor is adequate to describe the task variables. When the four subject matter fields are studied jointly, language arts variables tend to sort onto a single factor, and mathematics variables tend to sort onto a different single factor. This is true for the analyses of both concepts and tasks, for both boys and girls. The science and social studies variables do not give a similar unambiguous picture; they tend to sort onto separate single factors, but instead there is some mixing of science and social studies concepts for both boys and girls and tasks for boys. The results suggest that Task 7 and perhaps Task 12 may be somewhat different functionally from the other tasks; this is interesting but unexplainable especially considering that Task 7 is logically related as a mirror image of Task 6. Perhaps the unusual, and probably unfamiliar, format of the items for Task 7 is somewhat responsible for this "extra" factor. For example, a Task 7 item might be:

What is <u>not</u> always true about birds?

A. They have wings.
B. They fly.
C. They have feathers.
D. They are two-legged animals.

In general, the factor data suggest that there is some kind of functional integrity of subject matter developed by the time students reach sixth grade; it is not known whether or not this is simply a function of the association which characterizes the teaching of a given subject matter, or whether it truly represents differential latent abilities for dealing with these subject matters.

SUMMARY OF COGNITIVE ABILITIES FACTORS

A summary of the comparable common factors for cognitive abilities is given in Table 2 of the handout; the order of the factors is arbitrary. The similarities across all four sets of analyses--1970 and 1971 for both boys and girls--can be seen clearly. A general observation is that the results are essentially the same for each of the analyses.

Comparable Common Factors 1 through 6 are the same for all four samples except that Numerical ability (CCF 3) did not appear for girls in 1970 and the Memory factor (CCF 5) did not appear for girls in 1971. In 1970, CCF 7 was tentatively identified as Spatial ability. CCF 7 was further clarified in 1971 and was named Simple Visualization; the tests on CCF 7 demand visualization of missing portions of pictures or figures. CCF 8 and CCF 9 exist only for girls in 1970; they were tentatively identified as Evaluation and Seeing Relationships. No attempt was made to further clarify these factors in 1971.

We conclude that seven latent cognitive abilities underlie the test batteries that were studied and that these are the same for both boys and girls. The seven abilities are: Verbal (comprehension of information presented in verbal- or pictorial-semantic content, including induction of classes); Induction (induction of classes when nonsemantic content is employed); Numerical (using numbers as cardinal numbers but not as nominal symbols); Word Fluency; Memory; Perceptual Speed; and Simple Visualization. The first six are six of the seven Primary Mental Abilities of the Thurstones. The seventh is similar to the Thurstones' Closure One. We regard the consistency of the 1970 and 1971 results with the Thurstone structure as an important substantive finding.

RELATIONSHIPS BETWEEN MEASURES OF CONCEPT ATTAINMENT AND COGNITIVE ABILITIES

We used an interbattery analysis to relate the cognitive abilities tests to the variables of the four subject matter fields. These factors are summarized in Table 3. The handout also includes information about the squared multiple correlations of achievement measures with the abilities tests and with the interbattery factors. Tables 6 through 9 give the details of the derived interbattery factors. We interpreted the A'A proportional to L solutions.

For Interbattery Factor 1, three types of variables appear for all four sets of analyses; they are Verbal ability variables, concept attainment measures for science, and concept attainment measures for social studies. IB-1 is the only interbattery factor on which these types of variables appear (except that for three science and seven social studies concepts also appear on IB-3 for cognitive abilities and concepts for girls). Additional ability variables appearing on IB-1 are those for Induction for three of the four sets of analyses (Induction is missing from cognitive abilities and concepts for girls), those for Memory for three of the four sets of analyses (Memory is missing from cognitive abilities and tasks for girls), and those for Simple Visualization for only one analysis (cognitive abilities and tasks for boys). For two sets of analyses, additional concept attainment measures on IB-1 are thirteen language arts concepts for boys and three language arts concepts for girls.

For Interbattery Factor 2, the same five types of variables appear for all four sets of analyses. These five types consist of Numerical, Word Fluency, and Memory abilities, and language arts and mathematics concept attainment measures. IB-2 is the only interbattery factor on which Numerical, Word Fluency, and mathematics variables appear (except for three mathematics concepts on IB-3 for girls). Memory variables appear on IB-2 for all four sets of analyses as

well as on IB-1 for three sets. All language arts tasks appear on IB-2; most language arts concepts for girls (10 concepts) and some for boys (6 concepts) appear on IB-2 whereas most language arts concepts for boys (13 concepts) and some for some for girls (3 concepts) appear on IB-1

Interbattery Factor 3 provides linkage of the two types of variables only for girls for concepts.

The relationships among these cognitive abilities and concept attainment measures are very similar for both types of achievement measures: concepts and tasks. This suggests that, generally, concepts and tasks are not differentially related to cognitive abilities. However, there may be some concept-task interactions for language arts as indicated by the appearance of language arts concepts on both IB-1 and IB-2 for both boys and girls. Such an interaction was not clearly evident in the 1970 three-mode analyses; however, three-mode analyses were not performed on the 1971 data, and so this interaction is a possibility.

These general conclusions seem to be warranted: (1) achievement in science and social studies is related to three abilities--Verbal, Induction, and Memory; (2) achievement in language arts and mathematics is related to three abilities--Numerical, Word Fluency, and Memory; and (3) two abilities--Perceptual Speed and Simple Visualization--seem not to be related to achievement in these four subject matter fields.

A SUGGESTION FOR FURTHER STUDY

I will conclude by mentioning an experimental study that we propose be carried out. We suggest that practice in the particular cognitive abilities that we have observed to be related to specific subject matter concept attainment

may facilitate the learning of these concepts. To be specific, an eight group study for each subject matter (with the performance of the sexes considered separately) is suggested by the interbattery results. For science or social studies, one group would receive instruction only in the concepts of the subject matter; the other seven groups would receive this instruction plus instruction or practice in the tasks of Verbal, of Induction, of Memory, of Verbal and Induction, of Verbal and Memory, of Induction and Memory, or of Verbal and Induction and Memory. For either language arts or mathematics a similar eight group study could be designed employing the tasks of Numerical, Word Fluency, and Memory. These studies would have to be carefully designed and controlled, especially with respect to allocation of time and amount of practice. Further, this eight-group "incremental" design is not the typical completely crossed design of the textbooks and thus demands thought itself. These studies, or pieces of them, should be feasible however, and they would begin to answer questions about developmental relations between abilities and achievements.

We are aware that the aptitude-treatment interaction notion has intrigued persons and that we are here proposing something different. Rather than sorting students on the basis of aptitude and then searching for instructional procedures that interact with this stratifying or blocking variable, we suggest that particular "aptitudes" be practiced in conjunction with subject matter instruction in an effort to determine whether or not this learning transfers. This suggestion assumes that performance on the test tasks used to index selected aptitudes can be modified, whether or not one believes that the aptitude itself is being modified, and that these modifications may influence the acquisition of concepts in the subject matter field. Another speculation

would be that practice on the "aptitudes" may generate analogs of advanced organizers that can facilitate learning of the subject matter concepts.

I will now defer further discussion of this suggested line of research. If the notion strikes fire, we shall be pleased.

Table 1

Summary of Concept Attainment Factors

	Concepts		Tasks	
	Boys	Girls	Boys	Girls
1970 Single Analyses				
LA-1	Language Arts	Language Arts	Language Arts	Language Arts
M-1	Mathematics	Mathematics	Mathematics	Mathematics
Sc-1	Science	Science	Science	Science
SS-1	Social Studies	Social Studies	Social Studies	Social Studies
1971 Single Analyses				
LA-1	Language Arts	Language Arts	Language Arts	Language Arts
M-1	Mathematics	Mathematics	Mathematics	Mathematics
Sc-1	Science	Science	Science	Science
SS-1	Social Studies	Social Studies	Social Studies	Social Studies
1971 Combined Analyses				
CCF 1	Language Arts	Language Arts	Language Arts	Language Arts
CCF 2	Mathematics	Mathematics	Mathematics	Mathematics
CCF 3	Science	Science	Science Social Studies	Science
CCF 4	Social Studies Science	Social Studies Science		Social Studies
CCF 5		Language Arts (5)	Task 7-LA,M,Sc,SS Task 12-M,SS	Task 7-LA,M,Sc,SS Task 12-Sc,SS
CCF 6		Mathematics (2)		Tasks 3,4,5-Sc
CCF 7		Science (2)		
CCF 8		Social Studies (4)		

Table 2

Summary of Cognitive Abilities Factors

	1970		1971	
	Boys	Girls	Boys	Girls
CCF 1	Verbal	Verbal	Verbal	Verbal
CCF 2	Induction	Induction	Induction	Induction
CCF 3	Numerical		Numerical	Numerical
CCF 4	Word Fluency	Word Fluency	Word Fluency	Word Fluency
CCF 5	Memory	Memory	Memory	
CCF 6	Perceptual Speed	Perceptual Speed	Perceptual Speed	Perceptual Speed
CCF 7	Spatial (tentative)	Spatial (tentative)	Simple Visualization	Simple Visualization
CCF 8		Evaluation (tentative)		
CCF 9		Seeing Relationships (tentative)		

Table 3

Summary of Interbattery Factors

	Cognitive Abilities and Concepts		Cognitive Abilities and Tasks (Two-Factor Solutions)	
	Boys	Girls	Boys	Girls
Interbattery Factor 1	Verbal Induction Memory Language Arts Science Social Studies	Verbal Memory Language Arts Science Social Studies	Verbal Induction Memory Simple Visualization Science Social Studies	Verbal Induction Science Social Studies
Interbattery Factor 2	Numerical Word Fluency Memory Language Arts Mathematics	Numerical Word Fluency Memory Language Arts Mathematics	Numerical Word Fluency Memory Language Arts Mathematics	Numerical Word Fluency Memory Language Arts Mathematics
Interbattery Factor 3	Simple Visualization	Induction Mathematics Science Social Studies		